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PRE-DESIGN RADIATION SAFETY PLAN FOR THE OPERATIONAL TEST OF THE PULSED FAST NEUTRON ANALYSIS (PFNA) CARGO INSPECTION SYSTEM AT YSLETA PORT OF ENTRY COMMERCIAL CARGO FACILITY

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SYSTEMS RESEARCH AND TECHNOLOGY DEPARTMENT

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13. ABSTRACT (Maximum 200 words)

This document provides the radiation safety plan for the Pulsed Fast Neutron Analysis (PFNA) Cargo Inspection System facility at Ysleta Port of Entry Commercial Cargo Facility located in El Paso, Texas. It describes the PFNA facility and accelerator, discusses general operating procedures, covers personnel safety and radiation detection issues, and gives emergency procedures. An appendix is included that covers radiation safety procedures for PFNA system operation.

PFNA technology will be used for determining the presence of contraband, drugs, weapons, etc., in cargo containers and trucks. This technology measures the elemental contents (e.g., oxygen, nitrogen, etc.) within volume segments of a scanned object. These measurements are used to generate three-dimensional "maps" of the object's elemental composition. The amounts and relative concentrations of key elements are used to identify specific substances of interest (e.g., explosives, narcotics, etc.). A system has been designed to use this technology for inspecting vehicles, such as trucks and tractor trailers.

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FOREWORD

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Approved by:

R. NEAL CAIN, Deputy Department Head
Systems Research and Technology Department

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GLOSSARY

Accelerator
Includes the actual accelerator with its ion source, target cell, and associated equipment for the generation of neutrons.

Alternate Radiation Safety Officer (RSO)
An individual designated by the RSO and approved by the Radiation Safety Committee who, in the absence of the RSO, shall assume the authority and responsibilities of the RSO.

Controlled Area
The entire Pulsed Fast Neutron Analysis (PFNA) Facility (buildings, automated guided vehicle (AGV) routes, parking, etc.). Access to this area is regulated by United States Customs Service (USCS) personnel.

Exclusion Zone
The interior of the Inspection Building during the generation of the PFNA external neutron beam.

High Radiation Area
Any area where a person could receive a whole body dose of 100 mrem in any one hour up to 5000 mrem in any hour. For purposes of posting, an area where the whole body dose rate is (or might be) between 100 and 5000 mrem/hr.

Non-radiation Worker
A member of the general public.

Operator
A USCS employee trained in the operation of the PFNA System.

PFNA Facility
The buildings, AGV routes, parking areas, access roads, etc., that are contained within the fenced area.

PFNA System
The total scanning system including the accelerator, AGV, operator controls, and interlocks.

Radiation Area
Any area where a person could receive a whole body dose of 5 mrem in any one hour up to 100 mrem in an hour.

GLOSSARY (Continued)

Radiation Safety Coordinator
An individual who can assist in maintaining records related to radiation safety, act as a direct contact with the Radiation Safety Office (RSO), and assist in other duties at the discretion of the RSO. This individual must have adequate training and sufficient experience to function in the RSO's temporary absence.

Radiation Worker
A person who has received specific training and qualifications to make unescorted accesses into the controlled area and perform work of a radiological nature. The maximum permissible whole body dose for a radiation worker shall be no more than 5 rem in a year. Technicians who perform maintenance on the PFNA will be "Radiation Workers" to whom this higher occupational level applies.

Restricted Area
The interior of the PFNA Inspection Building or any area where access is controlled to ensure the radiological safety of personnel; these areas may contain radiological hazards that are identified by specific postings. Access to these designated areas by PFNA operators is restricted during production of an external neutron beam.

Unrestricted Area
An area to which access is neither limited nor controlled by the PFNA System operators.

Very High Radiation Area
An area where the dose rate exceeds 500 rad/hr a meter from the source. At Jefferson Lab, Newport News, Virginia, a more conservative definition is used – an area where the whole body dose rate is (or might be) above 5000 mrem/hr. See "whole body" and "whole body dose rate."

Whole Body
The portion of the body consisting of the head, trunk, and major blood-forming organs extending to the arms just below the elbow and the legs just below the knee. Whole body dose occurs when any of these portions of the body receive a deep dose.

Whole Body Dose Rate
Radiation level measured at a point 30 cm (approximately 1 foot) from the source of radiation or from any surface through which radiation emanates.

1 PFNA FACILITY

1.1 INTRODUCTION

PFNA technology will be used for determining the presence of contraband, drugs, weapons, etc., in cargo containers and trucks. This technology measures the elemental contents (oxygen, nitrogen, etc.) within volume segments of a scanned object. These measurements are used to generate three-dimensional "maps" of the object's elemental composition. The amounts and relative concentrations of key elements are used to identify specific substances of interest (explosives, narcotics, etc.).

A system has been designed to use this technology for inspecting vehicles, such as trucks and tractor trailers. The system, developed by Ancore Corporation, is called the Pulsed Fast Neutron Analysis Cargo Inspection System (PFNA-CIS). The system is housed in an "Inspection Building" and controlled from an operations center. A simplified diagram of the PFNA-CIS is shown in Figure 1.1.

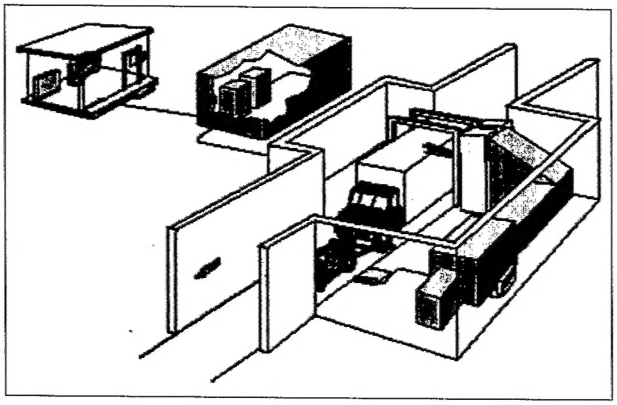

Figure 1.1 The PFNA-CIS is Composed of Several Components.

The accelerator will be employed for pulsed fast neutron activation analysis (PFNA), which is a Non-Intrusive Inspection (NII) Technology.

The accelerator used in PFNA is an electrostatic tandem type accelerator. The accelerated beam will consist of deuterons with kinetic energies of up to 6 MeV. The deuteron beam will strike a thin deuterium gas target, causing a D(d,n) He reaction that yields neutrons with kinetic energies of up to 9 MeV.

There will be no radioactive materials used for neutron targets, and there are no radioactive materials present in the accelerator. However, tritium is a by-product in a fraction of the nuclear reactions used for the production of the neutrons.

1.2 FACILITY LOCATION

A PFNA system developed by Ancore Corporation in Santa Clara, California, is to be installed at the Ysleta Customs Facility located in El Paso, Texas, shown in Figure 1.2-1. The layout of the facility is shown in Figure 1.2-2.

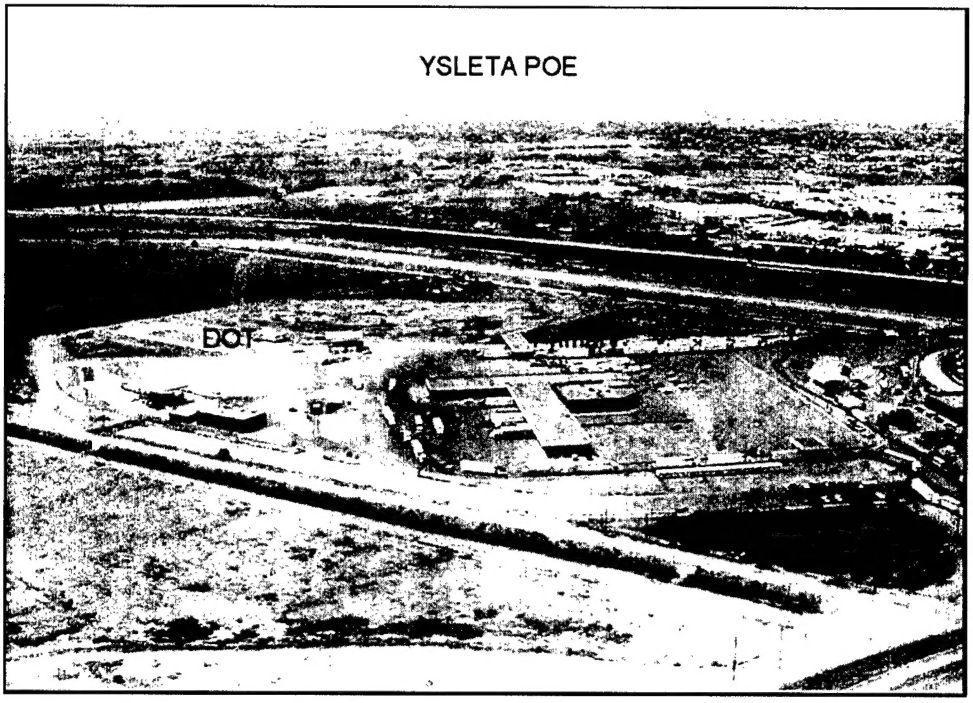

Figure 1.2-1 PFNA Site Location

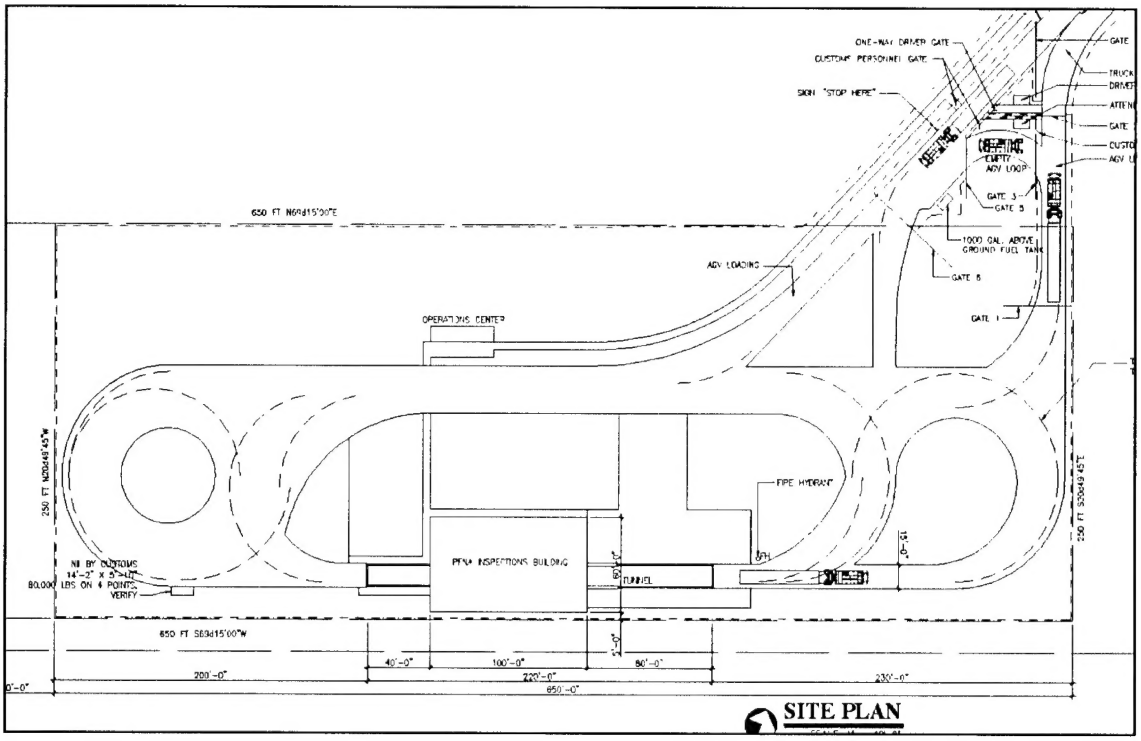

Figure 1.2-2 PFNA Facility Layout

Access to the building will be restricted. All outside doors to the PFNA Inspection Building will be kept closed and locked. If any doors are left opened or unlocked, they will be monitored by personnel located within sight of the doorway.

1.3 RADIATION SHIELDING

Figure 1.3-1 shows a top view of the proposed PFNA Facility buildings.

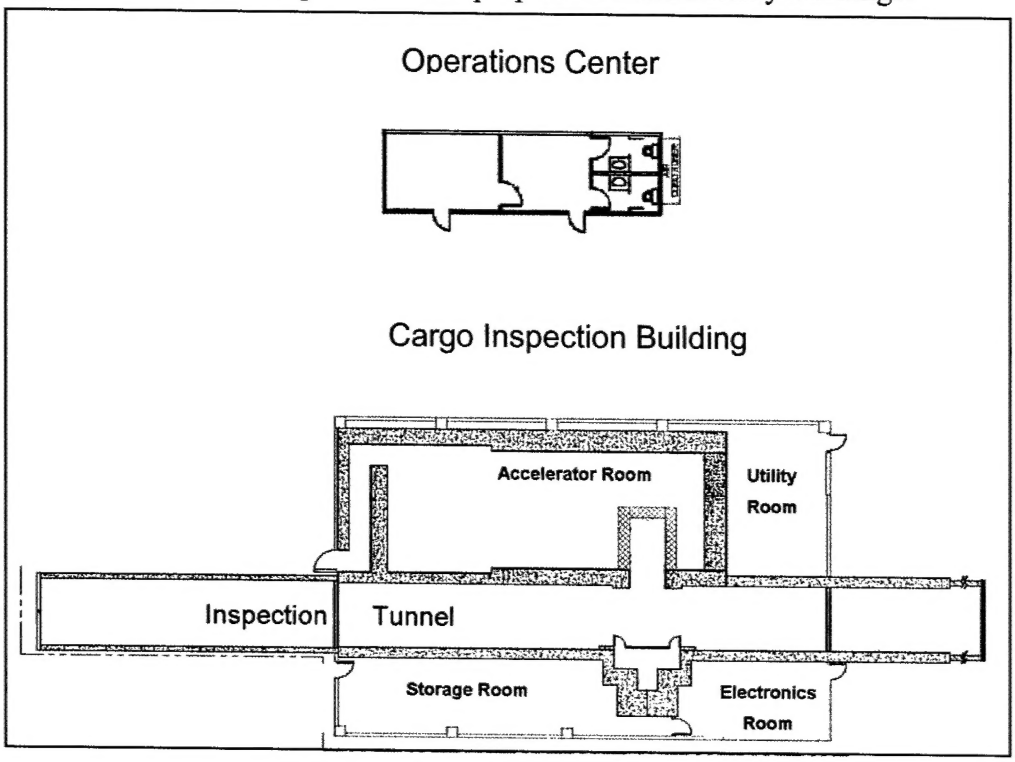

Figure 1.3-1 PFNA Buildings

The PFNA Inspection Building shielding will employ lead for gamma-ray shielding as well as concrete, boric acid, and wax mixtures for the neutron shielding. Area monitors will be placed in critical locations to assure that adequate shielding is being maintained. A detailed radiation survey map will be completed prior to operating the neutron generator at full output to ensure shielding adequacy. A record of periodic facility radiation survey maps will be maintained, and it will be revised every time the operating parameters of the accelerator are modified.

The time-integrated or effective dose rates at the boundaries of the Exclusion Zone will be kept below 50 μR/hr (50 microrem/hr) total neutron, x-ray, and gamma, as measured above the natural background level. The dose rate of 50 μR/hr was selected because an individual in the unrestricted area could receive a dose of 50 μR/hr x 2000 hrs/yr = 100 mrem; regulations state that an individual should not exceed 100 mrem/year. The dose rate at the ceiling of the PFNA Inspection Building will be kept to a level such that the dose to individuals located outside the vertical walls of the PFNA Inspection Building shall not exceed the 50 μR/hr. The system may not be operated when individuals are on the roof of the PFNA Inspection Building or above the vertical walls in an area where the radiation level exceeds the time-integrated or effective dose rate of 50 μR/hr. A complete radiation survey of the system is given in Table 1.3 below. The points referenced are shown in Figure 1.3-2.

Table 1.3 Radiation Survey Points

Radiation Measurement Locations	Background Reading	Date & Time of Reading	Radiation Reading
1. Inside operations building			
2. Inside accelerator room			
3. Inside tunnel, near beam			
4. Inside storage room			
5. Inside electronics room			
6. Outside building, behind beam stop			
7. Outside tunnel exit			
8. Inside tunnel between main door & electric roll door			
9. Outside entrance to accelerator room			
10. Inside utility room			
11. Outside building, near scan arm			
12. Where tunnel wall meets building wall			

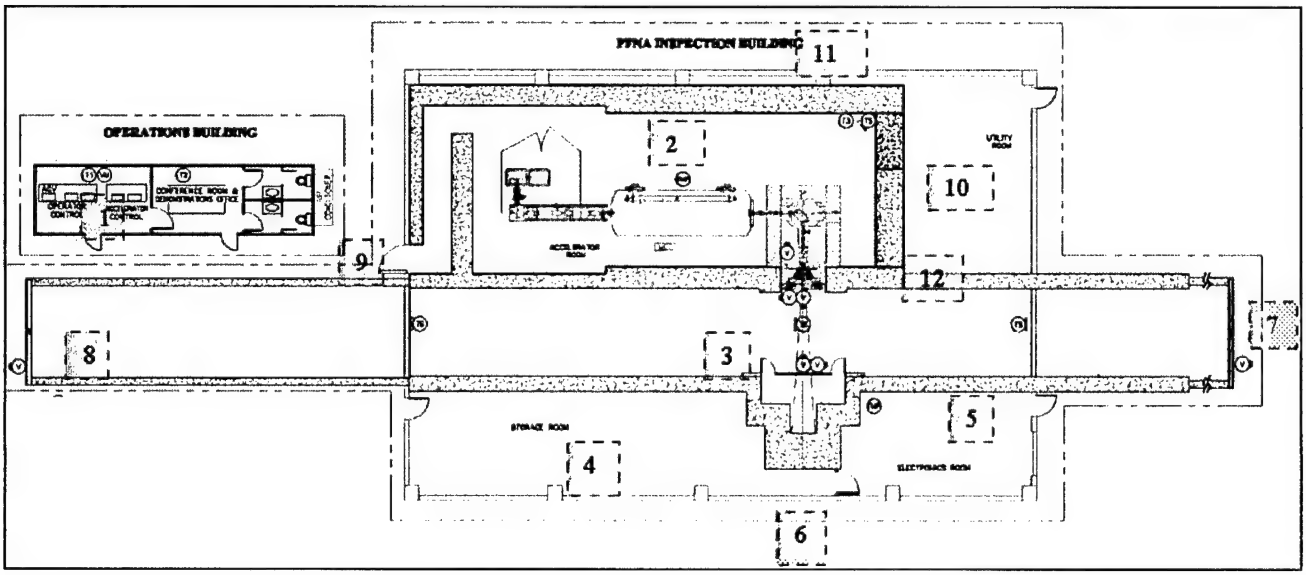

Figure 1.3-2 Survey Points

1.4 AREA MONITORS

The general location of the area monitors will be provided when the facility is constructed. However, the area monitors will be placed in the most critical location and will be relocated as necessary if radiation shielding is altered. The area monitor will be adjusted to alarm if the total neutron and gamma dose rates exceed 50 μR in an hour. The area monitor will supply data and a warning light to the operator and he/she shall use the emergency stop to stop the system and then investigate the cause for the out-of-limit measurements.

Calibration of the area monitors will be checked quarterly with a small calibration source. The dose rate from the calibration source will be measured employing a portable calibrated neutron and/or gamma survey meter, which are/is referred to in Section 4. The alarm settings will be tested to ensure alarm activation and safety interlock of the generator. The safety emergency stop will cause the high voltage of the accelerator to be shut off and will insert the beam cups automatically; hence, no neutron production will occur.

A thermoluminescent dosimeter (TLD) similar to that used for personnel dosimetry shall be placed at the highest dose rate ports on each of the four walls and the ceiling surrounding the restricted area. The TLD badges shall be capable of detecting neutron, gamma, and x-ray exposure and shall be replaced monthly. A record of the TLD badge doses shall be maintained for a period of five years.

1.5 PERSONNEL ACCESS

1.5.1 Entry Immediately After Accelerator Operation

After long irradiation periods, delayed radiation can be emitted from activated materials in the target area. The areas of highest activation would be the neutron production target and materials within its immediate vicinity. Dose rate measurements shall be initially conducted to determine a safe waiting period prior to entry into the radiation area and/or access to the target vicinity. The waiting period shall be long enough to ensure that dose rates to individuals entering the restricted area are less than 50 μR/hr or 2 mrem/hr for radiation workers.

1.5.2 Authorized Personnel

Access to the areas of the Accelerator Room shall be limited to individuals that have been trained in radiation safety and in handling other safety hazards associated with the accelerator area. The Accelerator Room shall be locked whenever it is unoccupied. Only individuals designated as radiation workers shall have access to the Accelerator Room keys. Untrained individuals performing tasks in the Accelerator Room shall be under the supervision of a radiation worker.

1.5.3 Visitors

Visitors to the Accelerator Room shall be required to sign in on a visitor's logbook when they enter the room. If visitors are to enter this area they shall be issued a TLD badge. A record of TLD badge users and badge numbers shall be maintained. Visitors entering the Accelerator Room shall be under the supervision of a designated radiation worker.

1.6 RADIATION SURVEY

A radiation survey shall be completed prior to operating the neutron generator at normal neutron output. An initial radiation survey shall be completed and additional surveys shall be performed when significant modifications are made to the shielding, neutron production target, ion source, or interrogation area.

2 ACCELERATOR

2.1 DESCRIPTION OF THE ACCELERATOR

The neutron generator that will be employed is manufactured by National Electrostatics Corporation in Middleton, Wisconsin, and is a Model 10.5SDH-4 Pelletron Accelerator. National Electrostatics Corporation has been manufacturing accelerators since 1965 and has manufactured and installed over 30 Pelletrons. A top view of the Accelerator is shown in Figure 2.1.

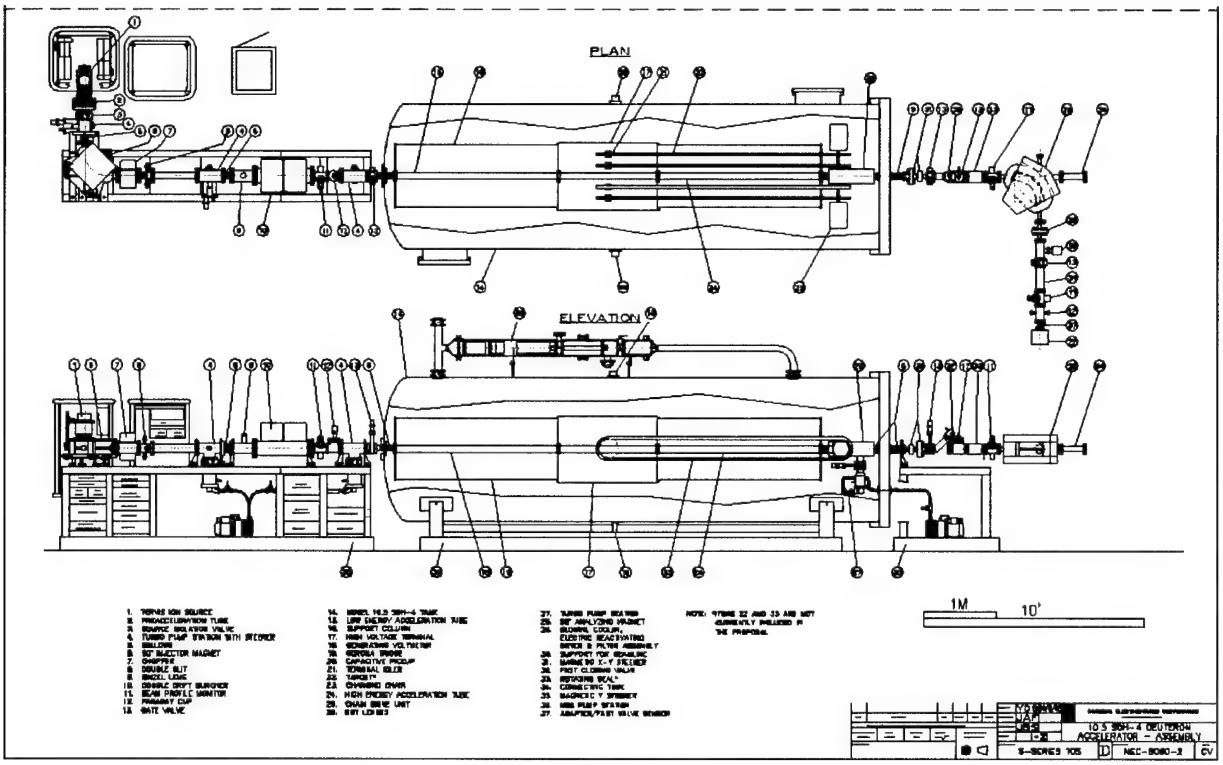

Figure 2.1 Pelletron Accelerator

The Pelletron is an electrostatic ion accelerator that employs two charging chains constructed of metal pellets. Typical operating deuteron energy is 6.5 MeV (terminal voltage 3.2 MV) with capability for 7 MeV. The pulsing system includes a double drift buncher (5/10 MHz) with 5 MHz primary frequency and high-voltage switch chopping at 2.5 MHz. The beam current shall be a minimum 75 μA in stable, long-term operation at 2.5 MHz. The accelerator is capable of producing deuteron beams with kinetic energies of 1 to 6 MeV and beam current up to

about 75 μA. Neutron production from the target would be about 2 x 10^8 n/sec at energies up to 9 MeV. The present target design is a 2-cm-thick cell filled with deuterium gas at a pressure of about 2 atmospheres. The pulse width of the neutron beam is about 1 nsec.

2.2 GENERAL OPERATING PROCEDURES

2.2.1 PFNA System Operators

The initial operators of the PFNA System shall be trained by the manufacturer's representatives. A member of the USCS Radiation Safety Committee (USCS-RSC) shall be present during operator training. The USCS-RSC shall develop a PFNA System operations course. This course shall be given when new operators are assigned to the system.

The Radiation Safety Officer (RSO) or Alternate RSO shall ensure that operators are trained in the radiation hazards associated with the operation of the PFNS System.

2.2.2 Securing the Exclusion Zone for Operation

The PFNA System operator shall assure that there are no personnel in the Exclusion Zone and that the all PFNA Inspection Building doors have been closed.

If interlocks are to be bypassed for maintenance reasons, or if someone is to be present in the Exclusion Zone while the machine is energized, prior written approval shall be obtained from the RSO or his/her alternate.

2.2.3 PFNA System Start-Up Procedures

The following is a list of procedures that shall be followed by the PFNA System operators before allowing the PFNA System to produce neutrons.

a. Inspect the Accelerator Room and assure that no personnel are in the area.
b. Inspect the shielding to assure that physical changes have not been made that would affect radiation exposures.
c. Verify that the Accelerator Room door is closed and locked.
d. Confirm that the warning horn and warning light are properly working.
e. Begin the system start-up routine from the operator's console.

2.2.4 PFNA System Scan Procedures

The following is a list of tasks that shall be performed before initiating a scan.

a. Inspect the Exclusion Zone and assure that no individuals are in the area.
b. Confirm that the warning horn and lights have been energized automatically.
c. Prior to generation of the PFNA System's external neutron beam, the tunnel area shall be visually verified empty of personnel by the PFNA System operator, and the access doors shall be closed and interlock switches set. There shall be a physical input by the PFNA System operator to verify that this inspection has been done before the scan can proceed.
d. Initiate the scan routine from the operator's console.

2.2.5 PFNA System Shutdown Procedures

The following is a list of tasks, which shall be performed before anyone may enter the Accelerator Room.

a. Initiate the system shutdown routine at the operator's control panel.
b. Verify that the system warning lights are off.
c. Confirm that the remote area monitor dose rate meter reading is at an acceptable level.
d. Remove the interlock key from the control panel.

2.2.6 Radiation Safety Procedures for PFNA System Operation

Appendix A describes safety equipment, administrative responsibilities, and general procedures for PFNA System operation.

A copy of the PFNA System start-up procedures, shutdown procedures, and the radiation safety procedure shall be posted on or near the PFNA System control console.

2.2.7 Safety Interlocks

The following safety interlocks shall be connected and tested prior to start-up of the accelerator. Interlocks shall be wired in a fail-safe manner, and any out of specification condition shall stop the generation of the accelerator's external neutron beam.

Safety interlocks will accommodate PFNA Cargo Inspection Equipment maintenance modes that differ from the PFNA Cargo Inspection Equipment operating mode. Maintenance workers could receive a radiation dose that is consistent with performing their duties under the "Federal Radiation Standards."

When a safety interlock system has been tripped, it shall only be possible to resume operation of the accelerator by first manually resetting controls at the position where the safety interlock has been tripped and then at the PFNA System operator's control console.

a. Accelerator Room Interlock
   If the door to the Accelerator Room is opened, no neutron production can occur.
b. PFNA Inspection Building Interlock
   If any of the doors to the PFNA Inspection Building are opened, no neutron production can occur.
c. PFNA System Interlocks
   The speed of the vehicle through the PFNA Inspection Building, the speed of the scan arm of the PFNA System, and the beam intensity shall be monitored and the generation of the PFNA System's external neutron beam stopped automatically should the system be operating at levels that exceed normal parameters or that approach the levels of this requirement.

d. Warning Horn and Light
All areas shall have observable indicators that the accelerator is on but not generating an external neutron beam.

Each location where an individual could receive a radiation dose in excess of 50 microrem in an hour and not have a peak measurement that exceeds 2000 microrem during this hour—and entrances to these locations—shall be equipped with easily observable warning lights and horns that operate when, and only when, radiation is being produced.

When a scan is initiated, an automatic 10-second delay shall be initiated prior to the accelerator being able to produce an external neutron beam. The warning alarm shall be activated for the 10-second delay period to alert people in the Exclusion Zone if they were missed during the PFNA System operator's inspection of the area.

3 PERSONNEL

3.1 RADIATION SAFETY OFFICER

The Radiation Safety Officer (RSO) reports directly to the U.S. Customs Operations Manager, who is the highest-ranking manager at the facility. The RSO has complete authority over radiation safety matters. The work is coordinated with that of the Operations Safety Officer who deals with non-radiation safety issues.

The RSO is listed below:

Richard T. Whitman U.S. Customs Service

3.2 PFNA SYSTEM OPERATORS

PFNA System operators shall be trained (see Section 2.2.1) in the radiation hazards associated with the operation of the accelerator by the facility RSO or Alternate RSO.

3.3 PERSONNEL RADIATION MONITORING

3.3.1 Thermoluminescent Dosimeters (TLDs)

All personnel who enter the Accelerator Room of the facility shall be required to wear a Luxel Optically Stimulated Luminescence (OSL) Dosimeter that contains gamma and neutron capability. The TLD badges are supplied and processed on a monthly basis by Landauer, Inc., of Glenwood, Illinois. The TLD badges monitor exposure to x-rays and gamma, beta, and neutrons. In addition, a Bubble Detector Neutron Dosimeter (BDND) will be assigned to each individual who is authorized to enter the Accelerator Room.

The TLD badge reports shall be reviewed by the RSO or Alternate RSO when they are received. All reported doses above 25 mrem shall be investigated by the RSO or Alternate RSO and corrective action shall be taken as needed.

3.3.2 Pocket Dosimeters (pagers)

If it becomes necessary for anyone to work inside the restricted area when the generator could be or is producing an accelerated beam of any kind, a pocket dosimeter shall be worn. The dosimeter is described in Section 4.

The dosimeter shall be set to supply an audible alarm for each 0.1 mrem of gamma-ray or x-ray dose. The pocket dosimeter is capable of supplying a continuous alarm. The continuous alarm level shall be set at a dose specified by the RSO.

3.3.3 Allowable Personnel Exposure

a. Controlled Area
   Radiation levels in the controlled areas shall be As Low As Reasonably Achievable (ALARA), but in no case shall they exceed a radiation level where a person could receive a whole body dose in excess of 100 mrem in any one year.
b. Exclusion Zone
   The effective dose rate at the boundary of this zone is 0.05 mrems/hr. Entry of personnel is not allowed inside this zone when the system is in operation. Only authorized personnel wearing film dosimeters or TLDs are allowed inside this zone in case of an emergency.
c. Restricted Area
   The time integrated or effective dose rates at the boundary of the area will be kept below 50 μR/hr when the accelerator is on and producing neutrons. Restricted areas will be posted with the following warning signs.

   "Caution Radiation Area"
   "This Equipment Produces Radiation When Energized"
   "Restricted Area, Authorized Entrance Only"

4 RADIATION DETECTION INSTRUMENTS

The following Table (Table 4) is a list of portable survey meters that will be available for use by the RSOs and PFNA System operators. These meters will be stored in the PFNA Operations Building and clearly marked.

Table 4 Radiation Survey Equipment

Manufacturer & Model	Description	No.	Purpose
Inovision Model 451P	Accessorized Ionization Chamber Range 0-500 μR/hr, 0-5 μR/hr	2	Radiation surveys of x-ray, beta, and gamma dose rates
Victoreen Model 190N	Moderated BF_3 Detector Range 0 mrem/hr to 75 Rem/hr	1	Radiation surveys of neutron dose rates
Victoreen Model 808E-100 VAMP	Halon-Quenced GM Tube	6	Area monitors, wall-mounted; measures gamma + x-ray dose rates

Table 4 Radiation Survey Equipment (Continued)

Manufacturer & Model	Description	No.	Purpose
Neutron Bubble Detectors Model BDPND[1]	Neutron Bubble Dosimeter 0.1-500 mrem (0.33-33 bubbles/mrem)	6	Area monitors, wall-mounted; measures neutron dose rates

Calibration of the survey instruments listed above will be completed every six months by a certified calibration facility. The area monitor will be calibrated every three months by the RSO or Alternate RSO.

5 POSTING OF NOTICES AND DOCUMENTATION

A bulletin board will be located near the entrance doors of the PFNA Operations Building. The bulletin board will display the following notices and documents:

- Texas Radiation Control Regulations
- License for Operation of an Accelerator or notice of where it is available
- Operating and Emergency Procedures and Emergency Phone Numbers
- Department Form RH-2364 (Notice to Employees)
- TLD badge reports from the preceding month
- Notices of violations involving radiological working conditions or any order issued pursuant to the Radiation Control Law
- Notice of any new hazardous areas or changes in procedures
- Certificate of occupancy (if required)
- List of emergency contacts

6 EMERGENCY PROCEDURES

In the event of a fire, earthquake, or other disaster, appropriate emergency agencies will be called and the RSO or Alternate RSO will be contacted immediately. The facility's Hazardous Materials Management Plan shall be on file with the City of El Paso Department of Public Safety.

In case of an accident involving exposure to radiation, all injured secured persons shall be removed from the radiation field if possible. The area involved shall be evaluated, secured, and roped off at a safe level. Emergency medical aid shall be called if needed and the RSO or Alternate RSO contacted.

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[1]In addition, these neutron bubble detectors can also be used as personal pocket dosimeters.

APPENDIX A

RADIATION SAFETY PROCEDURES

FOR PFNA SYSTEM OPERATION

Equipment

(A) A label bearing the words "CAUTION - RADIATION - THIS ACCELERATOR PRODUCES RADIATION WHEN ENERGIZED" shall be placed near the switch that energizes the accelerator.

(B) Any apparatus utilized in beam alignment procedures shall be designed in such a way that excessive radiation will not strike the operator.

(C) Any switch or device that may cause any component of the accelerator to produce radiation when actuated shall be located on a control panel or console and shall cause a warning light immediately adjacent to such switch to light; this light shall remain lit when, and only when, the associated control circuit is energized.

(D) All locations designated as high radiation areas, and entrances to such locations, shall be equipped with easily observable flashing or rotating red or orange warning lights that operate automatically when radiation is being produced. (orange: system on stand-by, red: system in operation)

(E) The entrance into the accelerator room shall be provided with an interlock designed to terminate radiation production for all possible modes of accelerator operation.

(F) Only a device on the accelerator control shall be used to turn the accelerator beam on and off. The safety interlock system shall not be used to turn off the accelerator beam, except in an emergency.

(G) The safety interlock shall not be dependent upon the operation of a single circuit; i.e., it shall be of redundant or fail-safe design.

(H) Circuit diagrams of the accelerator and the associated interlock systems shall be kept current and on file at the accelerator facility.

(I) A lock shall be provided on the control panel that prevents unauthorized operation of the accelerator.

(J) A warning horn shall be supplied that will give an audible warning to personnel in or near the designated radiation area at least 30 seconds prior to the accelerator producing radiation.

Administrative Responsibilities

(A) The facilities Radiation Safety Officer (RSO) or Alternate RSO (ARSO) is designated to be responsible for maintaining radiation safety. The RSO or ARSO will be responsible for the following:

(1) Establishing and maintaining operational procedures so that the radiation exposure of each worker is kept as far below the maximum permissible dose as is practical;

(2) Instructing all personnel who work with or near radiation-producing machines in safety practices;

(3) Maintaining a system of personnel monitoring;

(4) Arranging for establishment of radiation control areas, including placement of appropriate radiation warning signs and/or devices;

(5) Providing for radiation safety inspection of radiation-producing machines, including operation of all safety devices, on a routine basis;

(6) Reviewing modifications to apparatus, shielding, and safety interlocks;

(7) Investigating and reporting to proper authorities any case of excessive exposure to personnel and taking remedial action;

(8) Being familiar with all applicable regulations for the control of ionizing radiation; and

(9) Terminating operations at the facility because of radiation safety considerations.

(B) No individual will be permitted to act as an operator of the neutron generator until such person has:

(1) Received an acceptable amount of training in radiation safety as approved by the RSO;

(2) Demonstrated competence in the use of the accelerator, related equipment, and radiation survey instruments that will be employed; and

(3) Been approved by the RSO. Each operator shall be responsible for:

(a) Keeping radiation exposure to themselves and to others as low as is practical;

(b) Being familiar with safety procedures as they apply to the accelerator;

(c) Wearing of personnel monitoring devices, if applicable; and

(d) Notifying the RSO and ARSO of known or suspected excessive radiation exposures to themselves or others.

Operating Procedures

(A) Written operating procedures pertaining to radiation safety shall be established for the facility by the RSO.

(B) Written emergency procedures pertaining to radiation safety shall be established by the RSO and posted in a conspicuous location. These shall list the telephone number(s) of the RSO and ARSO and shall include the following actions to be taken in case of a known, or suspected, accident involving radiation exposure:

(1) Notifying RSO and ARSO;

(2) Notifying the PFNA Test Manager; and

(3) Arranging for medical examination.

(C) Operators and other appropriate personnel shall be familiar with and be given a copy of the written operating and emergency procedures pertaining to radiation safety. Such procedures shall be posted near the accelerator control console.

(D) The PFNA System shall be secured when not in operation to prevent unauthorized use.

(E) Personnel shall not expose any part of their body to the radiation beam.

(F) If, for any reason, it is necessary to temporarily and intentionally alter safety devices, such as bypassing interlocks or removing shielding, such action shall be:

(1) Specified in writing and posted on the control console and at the entrance requiring a safety interlock, so that other persons will know the existing status of the machine; and

(2) Terminated as soon as possible.

(G) The accelerator shall not be left unattended while energized, unless access to radiation areas or high radiation areas is physically prevented.

(H) Safety devices, such as horns, warning lights, and interlocks, shall be tested at quarterly intervals.

(I) Records of personnel monitoring results and safety device tests shall be maintained.

(J) Appropriate portable radiation monitoring equipment shall be available, properly maintained and calibrated, and sensitive to those radiations being monitored.

(K) An appropriate radiation monitor shall be used to ascertain that the radiation levels produced by accelerator operation are below maximum permissible levels.

(L) Personal radiation dosimeters measuring the expected radiations shall be worn by all persons operating the neutron generator and or entering a designated radiation area.

(M) Before the neutron generator is placed in routine operation, a radiation safety survey shall be made by a member of the USCS Radiation Safety Committee.

(N) A radiation safety survey shall be performed when changes have been made in shielding, operation, equipment, or occupancy of adjacent areas, and periodically to check for unknown changes and malfunctioning equipment.

(O) Records of all radiation safety surveys, inspections, and maintenance performed on the generator and related components shall be kept current and on file at the facility.

(P) The roughing pump used to pump the accelerator down to ion pump starting pressure is vented to the outside. The vent connection will be checked each time before pumping. A sign notifying personnel of this requirement will be maintained clearly visible to the pump operator.

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